

THE FRESHWATER ALGÆ OF THE PANJAB

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Part I.

BACILLARIOPHYTA (DIATOMEÆ)

With 6 plates

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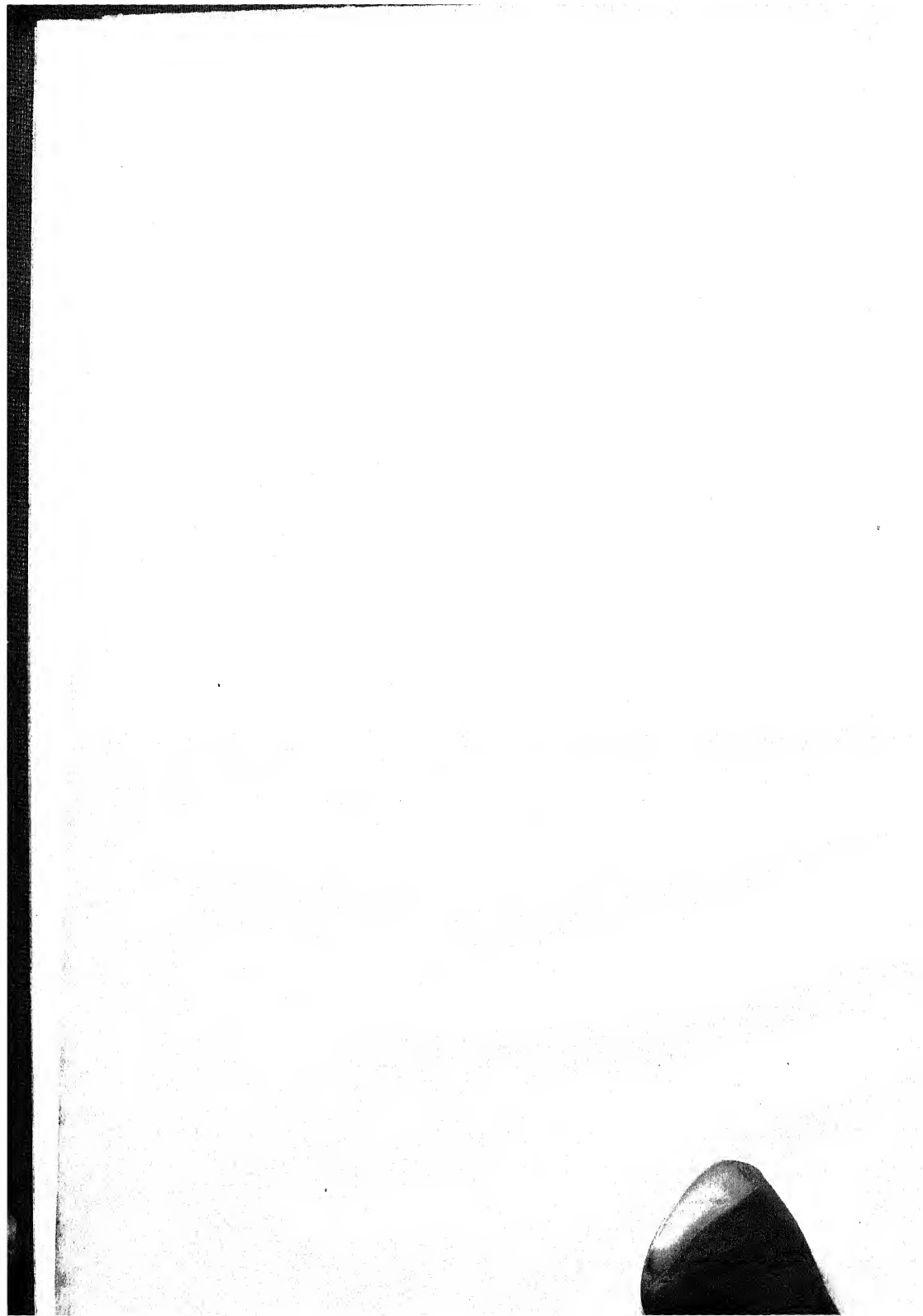
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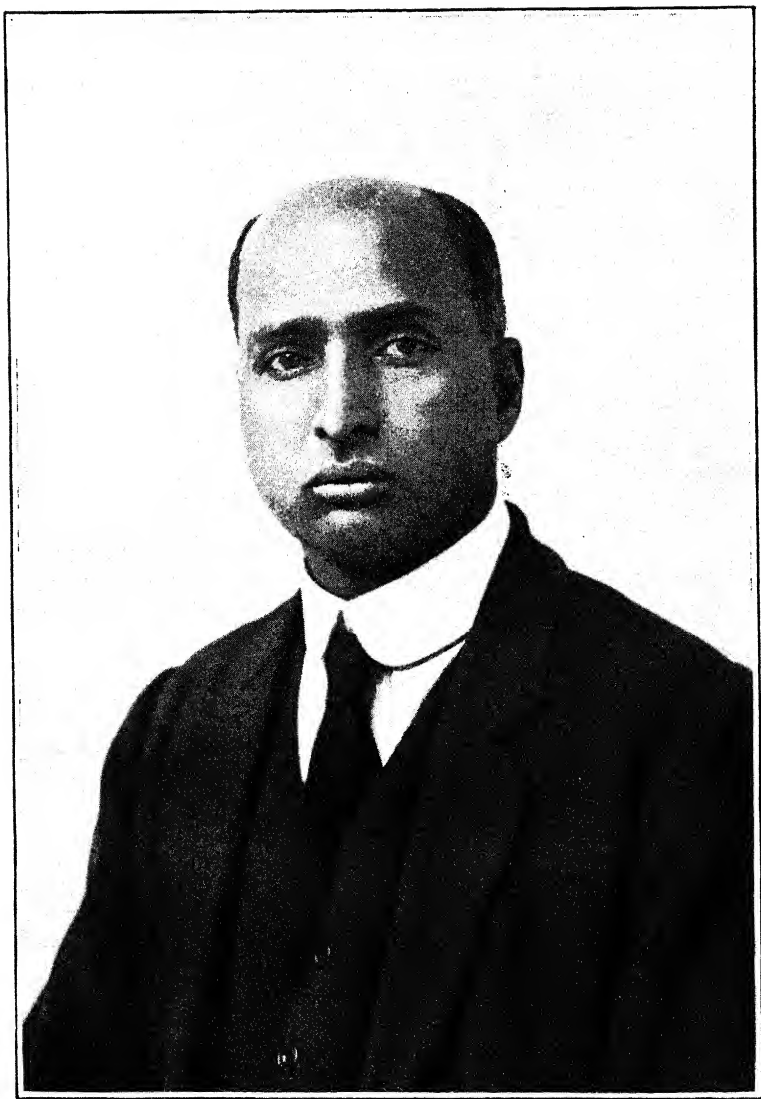
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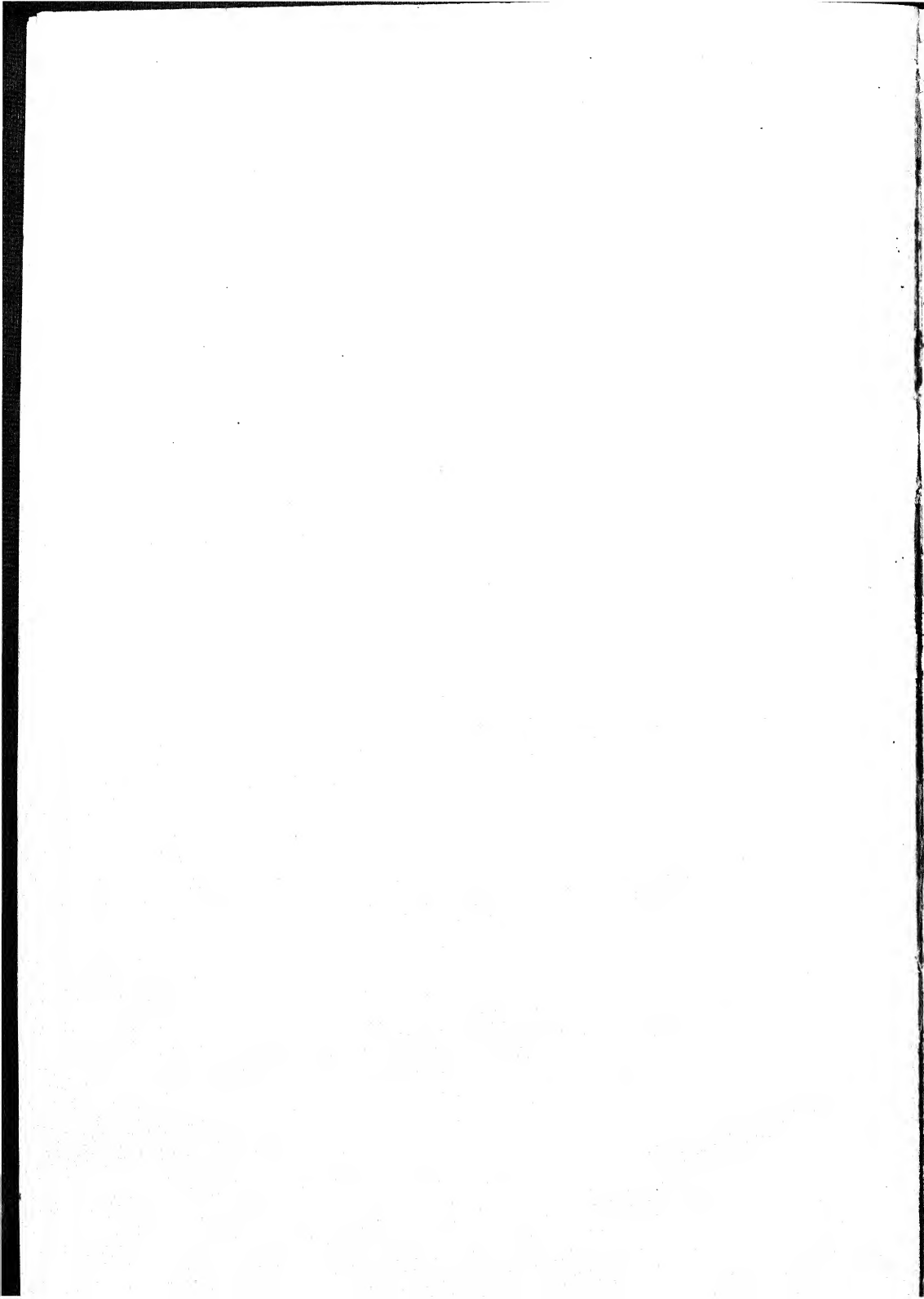
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To
The Memory
of
The Late Prof. S. R. Kashyap.



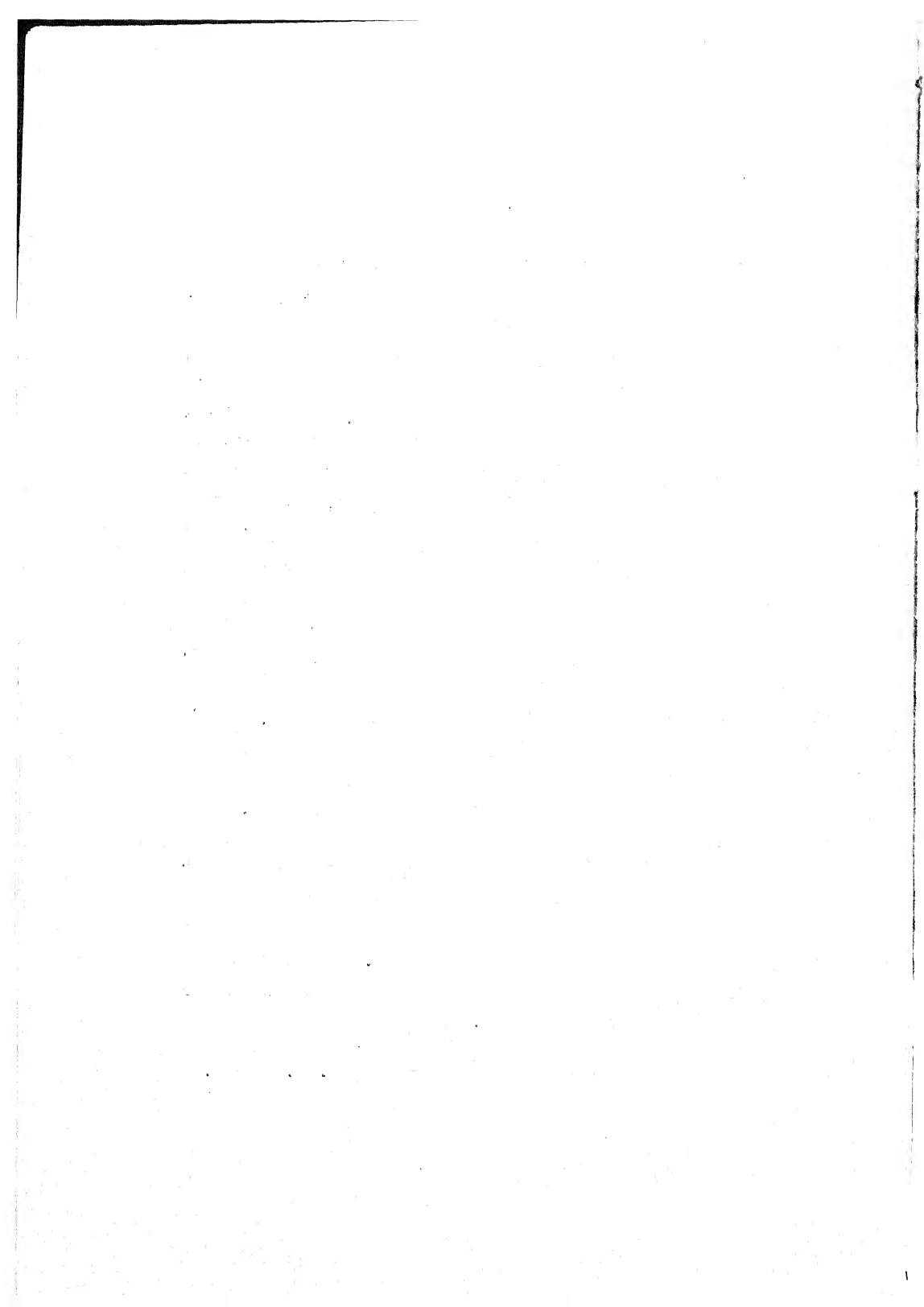


The late Rai Bahadur SHIV RAM KASHYAP, D.Sc. (Panjab), B.A. (Cantab.), I.E.S., F.A.S.B., Professor of Botany, the Panjab University, 1919-1934.



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Introduction.

In India not much attention has been paid to the study of Algæ. One of the first attempts towards this end as far as the Panjab is concerned was made by Dr. S. L. Ghose, whose work, however, is mostly on the Myxophyceæ. Other workers, W. and G. S. West, P. Brühl, M. O. P. Iyengar, K. Biswas, and Y. Bharadwaja have contributed to our knowledge of the algal flora from other parts of the country. Even then, the field of study remains vast and largely unexplored.

On the Diatomaceæ of the Province no work has so far been attempted; for this reason it was suggested to the writer to make a systematic study of the Diatoms inhabiting different localities in the Panjab.

The present attempt may, therefore, be regarded only as an introduction to more extended research in this direction which may be undertaken in the future.

THE COLLECTION AND PRESERVATION OF THE DIATOMS.

The Diatoms are very nearly ubiquitous. Wherever there is enough of moisture and light they are invariably found.

A search for the collection of Diatoms from the following habitats is sure to be profitably rewarded :—

1. In crop-fields or on road sides the standing water may frequently contain some species.
2. (a) At the surface of still ponds, pools and drains with some bad smell due to decaying organic matter, where a yellowish brown or sometimes greenish brown scum is formed. Ponds and pools and tanks are generally very rich in Diatoms.
(b) On submerged aquatic plants or filaments of Algæ in flowing streams and also in large ponds, where they coat them thickly. Rocks or pebbles constantly sprayed by water currents allow them to grow, but very rapid streams are poorer sources.
(c) At the bottom of ponds and tanks, where they lie as sediment.
3. In the digestive organs of fishes or other aquatic animals, because to some extent they serve as their food.
4. In the fossil state they are found at some places.

A large number of wide-mouthed small bottles or specimen tubes furnished with corks are indispensable for the outfit. The free-floating forms are collected by squeezing them out of the algal scum in a large specimen tube after having drained off the superfluous water, but if no tube is at hand they should be enveloped in a piece of rough paper or muslin or better still cellophane envelopes used for wrapping packages of

cigarettes and taken home to be preserved properly. Diatoms free or filamentous either sticking or epiphytically attached to submerged twigs, dead culms of aquatics should be collected in jars or big bottles. A spoon is frequently used in removing Diatoms from the surface of mud at the bottom of ponds and pools. This algal sludge can also be conveniently sucked in by using long pipettes. A muslin net or a spoon affixed to a long walking-stick or fishing-rod is often found helpful for sweeping off specimens from the places of the ponds which are otherwise beyond reach.

Diatoms are best examined and studied in a living state with a high power, because they display diverse movements under the eye of an observer. The writer found that if they were kept in a dish with sufficient amount of water in open air and diffused light of a laboratory room they could live even as long as a fortnight and would not undergo any deterioration or change in their contents.

2-4 per cent. solution of commercial formalin (40% formaldehyde) is found to be the most satisfactory preservative. A very weak solution of methylene blue has proved to be the best stain for Diatoms. The nucleus with the application of this stain is conspicuously stained before the rest of the protoplasm. Hæmatoxylin may also be used with profit.

It is very seldom that we find any gathering pure and ready for mounting and if ever found by chance, care must be taken not to allow such preserved material in the specimen tubes uncorked for a long time, because the dried-out specimens can never be revived. In order not to interfere with the determination of the species or even the genus the frustules of Diatoms must be cleaned and their inner contents completely destroyed. The method described by Bristol (5) has proved satisfactory. It, however, requires a good deal of patience and practice. It is as follows:—The material is placed in water on a glass-slide and broken up into very small pieces with a pair of needles. The water is allowed to evaporate slowly in the air, the slide being covered with a glass lid to prevent the access of dust. After 24 hours' drying the slide is placed

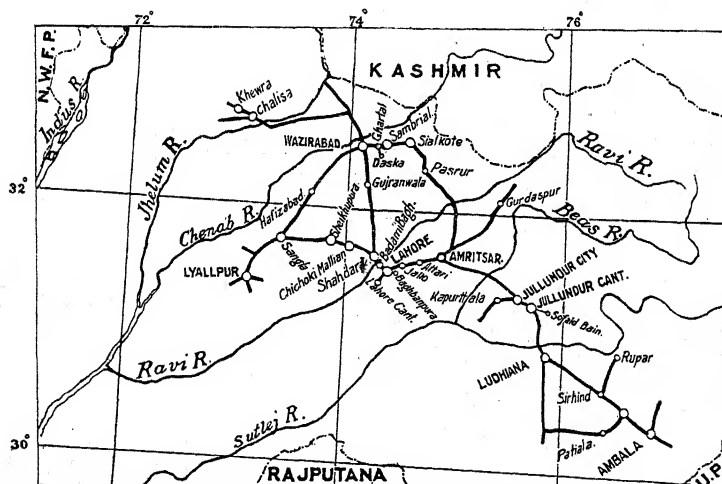
in a tube containing boiling strong HNO_3 and heated to remove all organic matter. After careful washing in water it is transferred through 95% alcohol and absolute alcohol to xylol. The film of the Diatoms still remaining attached to the slide is then mounted in Canada balsam.

Müller (26) recommends treatment with hot sodium carbonate and potash in studying the structure of the valves but I did not find it very useful in the case of stipitate forms. W. Smith (24) observes that these are to be immersed in spirits of wine and water—one part of the former to six of the latter in order to make them stiff.

During the preparation it is very difficult to keep the Diatoms isolated from other objects. In spite of the above-mentioned methods employed by me in most cases other objects had to be mounted along with the Diatoms.

THE DISTRIBUTION AND OCCURRENCE OF THE DIATOMS.

The material for these investigations constitutes a large number of collections which were made by the writer himself from many parts of the Panjab during the years 1931-33. The bulk of the collections come from Lahore and its vicinity, whilst the rest have been collected from important places, viz., Ambala, Rupa, Ludhiana, Jullundur, Amritsar, Sheikhupura, Gujranwala, Sialkote and Hafizabad, etc. The salt water collections were very kindly sent by Drs. S. L. Hora and H. S. Pruthi of the Zoological Survey of India, which they gathered from the Khewra Gorge and places near about in the Salt Range. A few unimportant places in this Province from where material was brought for the study are not mentioned here.



Map of the Panjab showing the principal localities from which collections have been made. (1931-1933)

The Diatoms are met with in fresh and salt water as well as on many subterrestrial places nearly at all times of the year in the Panjab. They are very scarce during the rainy

season but are most abundant in winter, i.e. mostly from the middle of November to the end of February, the latter period being most favourable for their rapid growth and development. It seems also that Diatoms enjoy a wide distribution in all kinds of habitats.

All these frequent collections from different places in the Panjab clearly show that the Pennales are far more richly represented than the Centrales.

Sub-aerial Association :—

After a rainfall and even a long time afterwards the bare wet garden lawns and diverse other moist places generally harbour species of *Nitzschia* and *Navicula* invariably mixed with other unicellular Algæ which give a greenish brown colour to the place. In such areas, as a rule, very minute specimens of the species of *Navicula* are mostly prevalent. The sides of drying ponds are frequently inhabited by *Navicula* sp., *Nitzschia subtilis*, *Cyclotella operculata*. During the months of November and December *Nitzschia vermicularis*, *Surirella ovalis*, *S. splendida* var. *minor* were met with abundantly on the sides of the ponds at Gujranwala, Sangla, Hafizabad and Ambala, etc. In the vicinity of Badami Bagh, from the sides of a drying pool overshadowed by shrubs and trees, species of *Nitzschia*, some *centric* forms and *Navicula cuspidata* var. *major* were secured in good quantities. In such localities after the water recedes around the edges *Eunotia arcus*, species of *Amphora* and *Synedra* were also seen. These forms are also met with, though never abundantly, in watered tennis-lawns, fields and damp pastures.

Aquatic Association :—

The Diatoms cannot stand very swift currents of water but when the current is slow, which is sometimes the case near the banks, they may be found attached to, or growing on some water-plants. From amidst the branches of a fallen tree just in the portion of the river Ravi near the Lahore Boat Bridge (1), where the flow of water was very rapid, muddy water was taken in a tube which on examination was found

to contain *Gyrosigma acuminatum*. The more or less isolated and stagnant or other small expanse of watery areas in the bed of the rivers provides a large number of Diatom specimens mixed with several other algal forms. In the river Sutlej at the Sirhind Canal Head Works the sides of the boats plying up and down the river were covered with long tresses of species of *Cladophora*, which had an abundance of colonial *Diatoma vulgare* and *D. elongatum* covering them. The channels known as the Small Ravi in Lahore, the Bhed Nala in Sheikhpura, the Budda Nala near Ludhiana and similar other streamlets in the Panjab, because of their slow flow of water abound in species of *Synedra*, *Gyrosigma* and *Amphora*, *Cymbella cistula*, and *Navicula radiosa* var. *acuta*. The brownish filaments of *Melosira varians* have often been encountered trailing along the water currents in these streamlets. Free-floating greenish masses on the surface of the slowly flowing water drains in gardens everywhere always bear *Anomoeoneis sphaerophora* in countless numbers. In drains and road-sides ditches emitting bad smell species of *Navicula* are most common and form a brownish filmy layer on their edges and also on their sides. They are also associated with species of *Cyclotella* and *Nitzschia*, and *Synedra ulna* var. *amphirhynchus*. In the small Ravi many a time it was seen that where the water is very slow and shallow species of *Cocconeis* and *Gomphonema* and *Epithemia* are found on the algal filaments attached to gastropod shells; they are also met with adhering to the grass-blades or forming a sort of coating on the gastropod shells themselves.

The ponds, pools, and tanks are the most productive places; in fact, they are the store-houses of Diatoms. *Synedra ulna* var. *amphirhynchus*, *S. affinis*, species of *Eunotia*, *Amphora ovalis* var. *gracilis*, *Anomoeoneis sphaerophora* float freely on the surface of the water. Interspersed amidst the stray filaments of some *Oscillatoria* spp. in pools, ponds and rapids of the Salt Range *Nitzschia palea* and *Cymbella helvetica* var. *curta* have been found. But at Daska and Ghartal (Distt. Sialkote) and Jullundur in most of the ponds the predominance of the Desmidiaceæ and Myxophyceæ has rendered the existence of

the Diatoms difficult. All the material collected therefrom presented only very minute specimens of the species of *Navicula*.

In pools, ponds and rapids of the Salt Range (11) species of *Nitzschia*, *Cyclotella Kützingeriana*, *Achnanthes hungarica* var. *linearis*, *Cymbella affinis*, *C. ventricosa*, and *C. helvetica* var. *curta* are attached to the sides of stones which when denuded of them and touched feel somewhat slimy. Species of *Synedra*, *Amphora ovalis*, *A. coffeaeformis*, *Gyrosigma acuminatum*, *Denticula crassula*, *Pinnularia interrupta*, *Cymbella cymbiformis*, *C. Ehrenbergii*, *Nitzschia palea* and *N. angustata* var. *genuina*, though not abundant, formed a portion of the collection from the salt pools.

The epiphytic Diatoms form the more interesting part of the study of the algal-flora of the Panjab. The filamentous algæ (e.g. *Cladophora* and *Chaetomorpha*) are found fringed with *Synedra affinis*, *Achnanthes hungarica*, *Cocconeis placentula*, *Epithemia argus*, *Gomphonema Ghosea*, *G. subapicatum*, *G. subapicatum* f. *curta*. They are of the most frequent occurrence in the pools of the Ravi, tanks of Hazuri, Shahdara and Shahlamar Gardens and Sofaid Bain near Jullundur Cantt. and similar other watery places in the Province. There they grow epiphytically by their mucilaginous hyaline stalks or attached to the surface of some submerged phanerogamous plants and other objects adhering to the sides of ponds and tanks. Sometimes the epiphytic Diatoms get detached from their substrata and float freely, mixed with other algæ. The most common ones of these are *Melosira varians*, *M. italica*, *M. crenulata*, *Synedra ulna* var. *amphirhynchus*, *Amphora ovalis*, *Navicula viridula* var. *rostellata*, *N. radiosa* var. *acuta*, *Cymbella cistula*, *Cocconeis placentula* var. *linearis*, *Epithemia turgida*, *E. Hyndmanni*, *Gomphonema capitatum*, *Rhopalodia gibba*, *R. gibberula*, *R. ventricosa*. *Cocconeis pediculus* occurs in profusion at Khewra Gorge and thickly clothes large filamentous Algæ and it appears to be the commonest of the Diatoms of the salt water. Individuals of *Hantzschia* and *Mastogloia* are occasionally met with but are too insufficient for specific identification.

A number of naviculoid forms are met with in these tanks on the sediment all mixed up with mud. Of these, *Diploneis elliptica*, *Navicula radiosa* var. *acuta*, *N. cuspidata* var. *major*, *Nitzschia vermicularis* and *Gyrosigma acuminatum* and *G. scalproides* form brownish slimy masses at the bottom. *Synedra affinis*, *S. rumpens* and minute species of *Nitzschia* are also found there.

Of all the Diatoms *Synedra ulna*, *Anomoeoneis sphaerophora*, *Navicula* sp. and *Nitzschia palea* are the most abundant and dominant in the Panjab. Gatherings from many localities in Lahore, Jullundur, Ludhiana, Ambala, Sialkote and Gujranwala have supplied specimens of these forms. Though rare in Lahore, species of *Surirella* (1), are commonly found in Gujranwala. Species of *Rhopalodia* and *Epithemia* seem restricted to the Central Panjab and form an intimate association. *Diatoma vulgare* and *D. elongatum* have so far been only found from the Sirhind Canal Head Works. No species of *Eunotia* and *Surirella* were encountered in the Salt water collections and it is also of interest to note that species of *Asterionella* and *Tabellaria* which are so prevalent in Europe, seem to be quite absent in the Panjab.

SYSTEMATIC ENUMERATION OF THE SPECIES OBSERVED.

The system of Classification followed is that given in Pascher's Die Süßwasser-Flora Mitteleuropas. Heft 10, Bacillariophyta, 1930. (2nd Edition by Fr. Hustedt.)

BACILLARIOPHYTA.

(Class DIATOMATAE.)

A. Order Centrales.

I. Suborder Discineæ.

1. Family Coscinodiscaceæ.

(a) Sub-family Melosiroideæ.

Genus *Melosira* Agardh, 1824.

Frustules usually cylindrical, concatenate, closely joined together by smooth sutural lines or by marginal teeth or spines to form long filaments. Girdle view rectangular, smooth or longitudinally striated. One or more annular ridge-like projections or internal constriction of the membrane (sulcus) in the middle. Valve circular with ornamentation in two parts, concentric to each other, radiate punctate. Chromatophores numerous and more or less circular. Auxospores frequently formed; microspore-formation too takes place.

1. *Melosira varians* Ag. Pascher 1930, p. 85, fig. 41;
West and Fritsch 1927, p. 354, figs. 146 C, D, E.

Frustules cylindrical forming long filaments. Girdle with an internal annular ridge-like projection. Valve circular, face devoid of markings. 15 μ in diameter. Protoplasts within the cells contain numerous small discoid chromatophores. Sometimes individuals show formation of auxospores. Length 45 μ , Breadth 33 μ .

Habitat: In ponds near Lahore. In pools formed by the overflow of water of the river Ravi. The long filaments always seen attached profusely to bricks in slowly flowing streamlets at Sheikhpura and Lahore. A wide-spread species.

December-January.

Plate I, figs. 1, 2, 3.

2. *Melosira italica* (Kütz.) W. Smith. Pascher 1930, p. 91, fig. 50; W. Smith 1856, p. 61, Pl. LIII, fig. 337.

Frustules forming long filaments, slightly curved at some joints. Margins denticulate at junction. Zone view with fine punctæ present in spirals. Valve circular, radiately punctate. 14-15 μ in diameter.

Habitat: Among brownish filaments squeezed out of water plants, in ponds near Lahore.

December.

Plate I, figs. 4, 5.

3. *Melosira crenulata* (Ehr.) Kütz. Boyer 1916, p. 15, Pl. 1, figs. 1, 2.

Frustules long and cylindrical with slight furrows at the suture. Finely punctate, punctæ forming indistinct rows. Junction-margin denticulate, valve circular with punctæ scattered at the centre, radiate at circumference. 15-20 μ in diameter.

Habitat: Among brownish filaments squeezed out of water plants, in ponds and tanks near Lahore. Rather rare.

October-December.

Plate I, fig. 6.

In some frustules numerous irregular internal annular ridges are also present.

(c) Sub-family Coscinodiscoideæ.

Genus *Cyclotella* Kützting, 1833.

Frustules solitary or geminate. Girdle rectangular or with undulate sides. Valve disc-shaped having two concentric

areas, inner smooth or with granules scattered and outer with finely punctate radiating striae. Chromatophores many, rounded. Microspores formed within the cells.

1. *Cyclotella Kützingiana* Thw. Pascher 1930, p. 98, fig. 62; W. Smith 1853, p. 27, Pl. V, fig. 27.

Frustules rectangular, undulate. Valve circular, 10–20 μ in diameter. Striae delicate, extending over half the disc, with middle area smooth.

Habitat: In pools, Salt Range, Khewra Gorge. In pools at Chalisa.

October.

Plate I, figs. 10, 11.

The species occurs in profusion in the Salt Range and has a considerable range in size.

2. *Cyclotella operculata* Kütz. Boyer 1916, p. 20, Pl. 2, figs. 5, 6; W. Smith 1853, p. 28, Pl. V, fig. 48.

Frustules in zone view undulate, a little depressed towards the centre, mostly forming pairs. Valve circular, 6–25 μ in diameter. Striae distinct, arranged radially, some thicker near the margin. Central area smooth.

Habitat: In a pond of stagnant water coating gastropod-shells appearing greenish brown, Shahlamar Garden, Lahore. On the edges of a drying pool at Nawankote, near Lahore.

December.

Plate I, figs. 7, 8, 9.

W. Smith 1853, p. 28 has described it as having 'striae obscure, very short'. Under the oil-immersion lens the striae are clearly visible and sometimes reach even up to the middle of the valve.

B. Order Pennales.

IV. Suborder Araphidineæ.

9. Family Fragilariaceæ.

(a) Sub-family Tabellarioideæ.

A. Section Diatomoideæ.

Genus *Diatoma* De Candolle, 1805.

Frustules rectangular, broadened at ends; cohering to one another by gelatinous cushions at the corners to form linear or zigzag chains. Valve linear or lanceolate or elliptical. Costæ transverse across the valve, touching the intercalary band in girdle, between them fine punctate striæ. Pseudoraphe narrow, indistinct in the middle. Chromatophores numerous, appearing like small rounded granules.

1. *Diatoma vulgare* Bory. Hustedt 1931, p. 96, figs. *a-d*; Boyer 1916, p. 42, Pl. 10, figs. 9, 11; W. Smith 1853, Pl. XL, fig. 309.

Frustules rectangular, solitary but mostly united to one another by gelatinous cushions at the corners in a zigzag chain, epiphytic on some filamentous Algæ. Valve elliptical with rostrate or capitate apices. Costæ pervious. Pseudoraphe narrow and indistinct. Chromatophores small and granular. Length 45–60 μ , Breadth 10–14 μ , Costæ 6–8 in 10 μ .

Habitat: Attached to yellowish brown threadlike filaments on stones in still water, sunny spots at the bank of the river Sutelj, Rupar. Abundant.

October–November.

Plate I, figs. 13, 14.

D. vulgare seems mostly associated with an old pale yellowish alga, perhaps *Cladophora*.

2. *Diatoma elongatum* Ag. Hustedt 1931, p. 99, figs. *a, b*; West and Fritsch 1927, p. 365, figs. *a-d*; Meister 1912, p. 62, Pl. V, fig. 18.

Frustules rectangular, solitary but usually in a linear or zigzag chain, sometimes stellately united with one another.

Valve linear, straight, elongated. Apices slightly rounded. Costate, costæ pervious. Length 30-45 μ , Breadth 3-5 μ , Costæ 6-7 in 10 μ .

Habitat: On and among threadlike filaments attached to rocks in still water, sunny spots at the bank of the river Sutlej, the Sirhind Canal Head Works, Rupar.

October-November.

Plate II, figs. 16, 17.

B. Section Fragilarioideæ.

Genus *Synedra* Ehrenberg, 1830.

Frustules solitary or in colonies, sometimes epiphytic. Girdle elongated with truncate apices. Valve straight, linear or linear-lanceolate. Ends attenuated or capitate or subcapitate. Striæ transverse, fine, absent or present in the central area. Pseudoraphe narrow and linear. Chromatophores two, platelike along the sides of the valve.

1. *Synedra ulna* var. *amphirhynchus* (Ehr.) Grun.
Hustedt 1932, p. 200, fig. 691A, e.

Frustules solitary. Girdle robust, elongated with truncate apices. Valve straight, linear or linear-lanceolate. Apices appreciably thinned and drawn out. Striæ punctate. Median area blank. Chromatophores 2, platelike with undulated edges and pyrenoids. Length 160-240 μ , Breadth 5-9 μ , Striæ 10-12 in 10 μ .

Habitat: In stagnant pools, ponds and tanks. In immense abundance. All over the Panjab.

October-February.

Plate II, figs. 1, 2.

The central area rectangular and being hyaline indistinctly discernible in some forms.

2. *Synedra capitata* Ehr. Hustedt 1932, p. 201, fig. 692.

Frustules robust, broad, linear. Valve long, linear, slightly thinned from the middle towards the poles. Apices

dilated into triangular heads. *Pseudoraphe* linear, narrow. Striæ punctate. Length 180–360 μ , Breadth at ends 8 μ , in middle 6 μ , Striæ 8–11 in 10 μ .

Habitat: Among brownish filaments sticking to the sides of a pond, near Lahore. In pools formed by the Buddha Nala at Ludhiana.

July–December.

Plate II, fig. 3.

3. *Synedra rumpens* Kütz. Hustedt 1932, p. 207, figs. *a*, *b*.

Valve solitary, linear, thinned towards the ends with the middle portion constricted and curved on one side. Apices slightly capitate. Central area hyaline. Striæ finely punctate. Length 60–80 μ , Breadth 4–6 μ at ends, 3 μ in the middle.

Habitat: In brownish scum formed on the sides of a drying pool, Ferozpur Road, Lahore. Rather rare.

December.

Plate I, fig. 16.

4. *Synedra affinis* Kütz. Pascher 1930, p. 159, fig. 184.

Valve solitary, narrow lanceolate. *Pseudoraphe* conspicuously wide. Striæ marginal and short. Length 95–120 μ , Breadth 3–5 μ , Striæ 10–12 in 10 μ .

Habitat: Among green filaments floating over water, Shahlamar Garden Tanks, Lahore.

November–December.

Plate I, fig. 15.

V. Suborder Raphidioidineæ.

10. Family Eunotiaceæ.

(*b*) Sub-family Eunotioideæ.

Genus *Eunotia* Ehrenberg, 1837.

Frustules solitary or united in pairs, free or epiphytic. Girdle more or less rectangular. Valve arcuate, transversely

striated. Striæ punctate. Apices rounded or subcapitate. Nodules fairly conspicuous, terminal, comma-like. Pseudoraphe absent. Chromatophore elongated with irregular lobes.

1. **Eunotia arcus** Ehr. Hustedt 1932, p. 282, figs. *a-c*;
W. Smith 1856, p. 13, Pl. XXXIII, fig. 283.

Frustules solitary, free. Valve arcuate, dorsal side smoothly convex, ventral nearly straight. Apices slightly produced, rounded. Striæ transverse, fine. Nodules terminal, comma-shaped. Length 39–60 μ , Breadth 7–9 μ , Striæ 10–12 in 10 μ .

Habitat: On the edges of a pond, in shade, Badami Bagh, Lahore. Rather rare.

January.

Plate II, fig. 4.

2. **Eunotia minuta** n.sp.

Frustules free and solitary. Girdle rectangular. Valve lunate with both margins concave. Ends broad and obtuse. Striæ delicate and indistinctly visible. Polar nodules present. Length 25–34 μ , Breadth 3 μ , Striæ 12–14 in 10 μ .

Habitat: Among *Hydrodictyon*-nets covering a vast area under the Small Ravi Bridge, Lahore. In drying pond overgrown with water plants, near Railway Station, Sialkote.

December–January.

Plate II, figs. 5, 6.

Valve narrow, lunate with broad obtuse ends, margins parallel concave, dorsal side not undulate. Nodules dot-like. Striæ indistinctly discernible at the poles. Length 25–34 μ , Breadth 3 μ , Striæ 12–14 in 10 μ . These are characters in which it differs from all the species described in Hustedt (1932). On account of its shape and concave parallel margins it is somewhat allied to *E. trinacria* Krass., but it should be considered as a new species.

VI. Suborder Monoraphidineæ.

11. Family Achnanthaceæ.

(a) Sub-family Cocconeioideæ.

Genus *Cocconeis* Ehrenberg, 1838.

Frustules in groups, epiphytic. Girdle transversely curved. Valves broadly rhomboidal to elliptical. Upper valve (epitheca) with axial pseudoraphe, lower valve (hypotheca) with median straight raphe and polar and central nodules. Striæ punctate, transverse in the middle, radiate towards the poles. Axil area rounded at the centre. Chromatophore single, plate-like with irregularly lobed margin. Auxospore formed by conjugation of two cells.

1. *Cocconeis pediculus* Ehr. Pascher 1930, p. 188, fig. 259.

Frustules epiphytic. Valves rhombic-elliptical, upper valve with a linear pseudoraphe; lower valve with raphe and indistinct nodules. Striæ punctate, radiating towards poles, punctæ fine. Length 21 μ , Breadth 15–20 μ .

Habitat: In a large pool in the course of a stream, sticking to pebbles and stones, Salt Range, Khewra Gorge.

October.

Plate II, figs. 12, 13.

C. pediculus is abundantly epiphytic on *Cladophora* and *Chaetomorpha* and sometimes it entirely covers the whole of the filament.

It may be regarded as a typical Diatom of the salt water.

2. *Cocconeis placentula* Ehr. West and Fritsch 1927, p. 370, figs. 155D-E; Meister 1912, p. 93, Pl. 12, figs. 5, 8.

Valves elliptical, upper with pseudoraphe; the lower with raphe. Striæ punctate, transverse in the middle and radiating towards the poles. Inter-marginal zone present. Length 24–26 μ , Breadth 15–25 μ .

Habitat : In tanks, water-reservoirs, ponds, epiphytically growing on blades of the *Typha* plant or other dead twigs submerged in water, Lahore and Ambala.

November, December and January.

Plate II, figs. 14, 15.

Individuals of *C. placentula* show a little change in their shape which has been caused by the objects to which these forms have adhered.

Cocconeis placentula var. **lineata** V.H.; Meister 1912, p. 94, Pl. XII, figs. 6, 7; Boyer 1916, p. 58, Pl. 16, fig. 29.

Valve elliptical, upper with a linear axil area. Punctæ radiating but towards the periphery irregularly arranged. As in the type, hyaline inter-marginal ring and raphe on the hypothecal valve. Length 39 μ , Breadth 25-27 μ .

Habitat : Epiphytic on some old filaments of *Vaucheria* and *Cladophora*, in a pond near Lahore.

December.

Plate I, figs. 17, 18.

(b) Sub-family Achnanthoideæ.

Genus **Achnanthes** Bory, 1822.

Frustules free or epiphytic. Girdle rectangular, longitudinally geniculate (or genuflexed). Valves linear or lanceolate. The upper valve (epitheca) convex with axial pseudoraphe, nodules absent; the lower valve (hypotheca) concave with raphe, stauros and inconspicuous nodules. Ends sub-acute. Punctae transverse, delicate. Chromatophore divided into many small granules.

1. **Achnanthes hungarica** Grun. West and Fritsch 1927, p. 369, figs. 155A-C; Pascher 1913, p. 56, fig. 101; Meister 1912, p. 98, Pl. XIII, figs. 5-6.

Frustules epiphytic and free-floating. Valves oblong, lanceolate. The upper (epitheca) with pseudoraphe, the lower

(hypotheca) with raphe and stauros. Ends acute or sub-acute. Polar nodules rather inconspicuous. Striæ dim. Length 20–23 μ , Breadth 6–8 μ .

Habitat: In pools, Salt Range, Khewra Gorge.
October.

Plate II, figs. 7, 8.

Achnanthes hungarica is met with in the salt water inter-mixed with *Cocconeis pediculus*.

***Achnanthes hungarica* var. *linearis* nov. var.**

Frustules epiphytic. Valves symmetrical, linear-lanceolate; epitheca with pseudoraphe and hypotheca with raphe and stauros. Girdle slightly constricted in the middle. Striæ dim. Length 15–30 μ , Breadth 3–5 μ .

Habitat: In pools in the course of a stream, Salt Range, Khewra Gorge.

October.

Plate II, figs. 9, 10, 11.

Individuals occur in profusion in the salt water and are found in groups attached to some filamentous algæ. The valves are linear-lanceolate and the apices are slightly rounded. These characters make it a new variety.

VII. Suborder Biraphidineæ.

12. Family Naviculaceæ.

(a) Sub-family Naviculoideæ.

Genus *Gyrosigma* Hassall, 1845.

Frustules solitary and free-floating, lanceolate. Girdle straight and linear-oblong. Valve convex, sigmoid, gradually attenuated towards acute or broadly rounded poles. Striæ in two delicate sets crossing one another at right angles. Median line (raphe) with sigmoid curvature. Central and polar

nodules present. Chromatophores two or more, elongated with irregular outline and lie on opposite sides of the girdle.

1. **Gyrosigma acuminatum** (Kütz.) Rabh. Pascher 1930, p. 222, fig. 329; Meister 1912, p. 119, Pl. XVIII, fig. 1.

Frustules solitary. Valve sigmoid, gradually tapering from the middle towards obtuse ends. Flexure considerable. Striæ not distinct. Median line and central nodules clear. Length 100–120 μ , Breadth in middle 15 μ , at ends 4 μ .

Habitat: At the edges and bottom of drying pools and ponds in Lahore and its vicinity, Sangla and Jullundur. In muddy water of the river Ravi. In a pond beyond Railway Station Sodi, Khewra Gorge. Commonly abundant.

October–February.

Plate III, fig. 6.

Specimens found on moist earth are mostly sigmoid with their median line showing a considerable curvature near the ends. Polar nodules undeveloped.

(Note:—*Pleurosigma* and *Gyrosigma* should not be separated. They differ because of the two sets of striations which cross one another either at right angles or obliquely. This can also make an important differentiating character of the species).

2. **Gyrosigma scalproides** (Rabh.) Cl. Pascher 1930, p. 226, fig. 338; Cleve 1894, p. 118.

Frustules solitary. Valve sigmoid, linear, ends rounded, a little oblique. Median line nearly straight, central nodule large and conspicuous. Striæ dim. Length 54–70 μ , Breadth 10 μ .

Habitat: In pools of stagnant water, Shahdara, near Lahore. In pools and ponds at Gujranwala.

January.

Plate III, fig. 7.

The form of this species is rather variable. They are often met with mixed with *G. acuminatum*.

3. **Gyrosigma tenuissimum** W. Smith. W. Smith 1853, p. 66, Pl. XXII, fig. 213; Cleve 1894, p. 117.

Frustules solitary. Valve sigmoid, linear-lanceolate very narrow, with central longitudinal line and nodule in the middle. Apices acute. Striæ not visible. Length 75–110 μ , Breadth 5–8 μ .

Habitat: Amongst other Diatoms forming brownish filmy layer on some water plants, Shahlamar Garden Tanks, Lahore.

November.

Plate III, fig. 8.

The striæ in *G. tenuissimum* are very inconspicuous so much so that even the high power employed fails to show them.

Genus **Diploneis** Ehrenberg, 1840.

Frustules rectangular. Valve elliptical. Central nodule prolonged into horn-like processes, which enclose the straight raphe. Costæ transverse, punctæ coarse.

1. **Diploneis elliptica** Kütz. Pascher 1930, p. 250, fig. 395; West and Fritsch 1927, p. 372, fig. 161 c; Boyer 1916, p. 84, Pl. 20, fig. 14; Meister 1912, p. 104, Pl. XIV; fig. 6.

Valve elliptical, with median line enclosed in horns. Striæ radiate, coarsely punctate. Length 40–64 μ , Breadth 16–32 μ , Striæ 9 in 10 μ .

Habitat: In pools formed by the overflow of water of the river Ravi, near Lahore. In sunny pond outside Dak Bungalow, Hafizabad.

In pools formed by rapids and falls at water-reservoir, Salt Range, Khewra Gorge. Not very common.

December–January.

October (in salt water).

Plate I, fig. 20.

2. **Diploneis puella** (Schu.) Cl. Pascher 1930, p. 250, fig. 394; Cleve 1894, p. 92.

Valve solitary, elliptical. Central nodule large, quadrate. Furrow narrow. Alveoli indistinct. Length 20–25 μ , Breadth 15–18 μ , Costæ 12–14 in 10 μ .

Habitat: In pools near the Sirhind Canal Head Works, Rupar.

October–November.

Plate I, fig. 19.

Genus **Anomoeoneis** Pfitzer, 1871.

Frustules rectangular, linear. Valve elliptic-lanceolate. Ends rostrate-capitate. Raphe straight. Axial area narrow. Striæ transverse, delicate with wavy blank longitudinal spaces on the valve-face. Chromatophore single, laminate with pyrenoids.

1. **Anomoeoneis sphærophora** (Kütz.) Pfitz. West and Fritsch 1927, p. 372, fig. 156 c; Cleve 1895, p. 6.

Valve elliptic-lanceolate. Ends rounded and produced. Raphe clear. Striæ indistinct. Length 100–160 μ , Breadth 27 μ .

Habitat: In greenish masses floating over water, garden streamlets, pools, ponds, and tanks. All over the Panjab. Abundant.

April–July, October–February.

Plate III, fig. 9.

I have a little doubt as to the identity of this species. The individuals clearly resemble West and Fritsch 1927, fig. 156 c, in having elliptic-lanceolate valve, median raphe, and the parietal and lobed chromatophores occupying a greater portion of the valve. The punctæ are not clearly discernible in some specimens, even with the oil-immersion lens.

Genus *Navicula* Bory, 1822.

Frustules free-floating, solitary or in colonies. Girdle straight, rectangular. Valve linear, lanceolate or fusiform. Ends capitate, rounded or rostrate. Raphe straight with central and polar nodules. Striæ or costæ transverse, parallel or radiate. Axial area narrow, linear. Chromatophores two, laminate, lie on both sides of the valve with a bridge-like connection in the middle; sometimes they are split up into numerous small rounded granules.

Section *Naviculæ Orthostichæ* Cleve.

Valves elongated, linear-lanceolate. Median line straight with indistinct terminal fissures. Punctæ in transverse and longitudinal rows, crossing each other at right angles.

1. *Navicula cuspidata* var. *major* Meister. Meister 1912, p. 134, Pl. XX, fig. 10.

Valve elongated, rhombic-lanceolate. Ends produced and rounded. Axial area linear. Median line distinct. Length 142–170 μ , Breadth 32–37 μ , Striæ 12–18 in 10 μ .

Habitat: On the edges of a pond in shade, Badami Bagh, Lahore.

January.

Plate VI, fig. 1.

In most of the forms met with here the striæ are arranged in indistinct transverse and longitudinal rows; but in some I found the latter quite absent.

These forms are met with here greatly entangled in gelatinous masses of brownish yellow decaying algæ at the edges of the ponds.

Section *Naviculæ Lineolatæ* Cleve.

Valves elongated, broadly lanceolate or rhomboidal. Axial area narrow. Median line straight. Striæ transversely lineate, parallel or radiate.

1. *Navicula viridula* var. *rostellata* Cl. Meister 1912, p. 139, Pl. XXI, fig. 11 ; Cleve 1895, p. 15.

Frustules solitary. Valve broadly lanceolate with attenuated, subrostrate ends. Striæ radiate. Axial area narrow. Central area rounded. Length 50-60 μ , Breadth 8-10 μ , Striæ 10-12 in 10 μ .

Habitat : In brownish filmy layer covering some water-plants in Shahlamar Garden Tanks, Lahore. Rather rare.

November.

Plate II, fig. 18.

2. *Navicula radiosa* var. *acuta* Grun. Meister 1912, p. 140, Pl. XXI, fig. 12.

Frustules solitary. Valve narrow, lanceolate, gradually tapering from the middle to the acute ends. Axial area indistinct. Central area somewhat rounded. Striæ nearly radiate. Length 40-45 μ , Breadth 8-10 μ , Striæ 12-15 in 10 μ .

Habitat : In whitish slimy mass attached to sugar-cane pieces, in pools near the river Ravi Boat Bridge, Lahore.

January.

Plate II, fig. 19.

3. *Navicula* (?) sp.

Frustules solitary, free-floating and also in groups. Girdle linear, rectangular. Valve rhomboidal-lanceolate, obtuse at the produced ends. Raphe straight. Chromatophores two, green, elongated with a bridge-like connection in the middle. Length 18-25 μ , Breadth 8-10 μ .

Habitat : On moist earth. In pools, ponds, tanks, and water-reservoirs, Lahore, Gujranwala, Amritsar, Jullundur, Ludhiana and Ambala. Very common in the Panjab.

At all times in the year.

Plate II, figs. 22, 23, 24.

The striæ being quite indistinct, the species could not be identified. It, however, approaches to *N. pusio* Cl.

Navicula (?) sp. occurs in a wide variety of habitats and is an interesting form.

In living state it exhibits peculiar movements. Some of the individuals (3 or 4) arrange themselves in an irregular zigzag line, which after few seconds is broken up to form a star-like figure. The motion is always accompanied by jerks.

Genus *Pinnularia* Ehrenberg, 1843.

Frustules solitary and free-floating. Girdle linear-rectangular. Valve linear, sometimes gibbous in the middle. Ends broadly obtuse. Raphe straight or flexuose. Central and polar nodules expanded. Axial area broad. Terminal fissures straight or sigmoid. Striæ or costæ coarse, parallel or radiate with internal openings. Chromatophores two with pyrenoids.

1. *Pinnularia gibba* Ehr. Pascher 1913, p. 109, fig. 235; Cleve 1895, p. 82.

Valve linear, gradually tapering to the subcapitate ends. Raphe filiform with curved terminal fissures. Axial area linear widened around the central nodule. Striæ divergent in middle and convergent at ends. Length 65–80 μ , Breadth 10–13 μ , Striæ 10–11 in 10 μ .

Habitat: On the green perpendicular edges of the water-plant tanks, Botanic Garden, Lahore. Also among brownish mass sticking to some water-plant in a pool near Lahore.

December–January.

Plate III, fig. 10.

2. *Pinnularia interrupta* W. Smith. Fritsch and Rich 1929, p. 105, fig. 5F; W. Smith 1853, p. 59, Pl. XIX, fig. 184.

Valve linear with slightly convex sides. Ends capitate. Axial area dilated in the middle. Striæ delicate. Length 45–55 μ , Breadth 5–8 μ , Striæ 10 in 10 μ .

Habitat : In pools, rapids and falls above water-reservoir,
Salt Range, Khewra Gorge.

October.

Plate II, fig. 20.

(c) Sub-family Gomphocymbelloideæ.

Genus **Amphora** Ehrenberg, 1840.

Frustules asymmetrical solitary and free-floating. Girdle broadly elliptical with truncate ends. Valve sublunate, dorsal side convex, ventral side concave. Ends acute or obtuse. Raphe arcuate, situated near the ventral valve-face. Striæ punctate, radiate, delicate. Chromatophores split up into many granules.

1. **Amphora ovalis** var. **gracilis** V.H. Meister 1912, p. 183, Pl. XXXIII, fig. 10 ; Cleve 1895, p. 104.

Frustules solitary. Girdle elliptical with truncate apices. Valve lunate. Raphe curved. Striæ finely punctate, row of short striæ near the ventral surface. Length 20–40 μ , Breadth 10–15 μ , Striæ 9–12 in 10 μ .

Habitat : In pools, in Shahlamar Garden Tanks ; on the edges of water troughs in Botanic Garden, Lahore. In pools and ponds in Gujranwala, Amritsar, and Jullundur. Commonly found in the Panjab.

October–November.

Plate IV, figs. 7, 8.

2. **Amphora coffeæformis** Ag. Pascher 1930, p. 345, fig. 634.

Frustules elliptic-lanceolate. Valve convex on the dorsal side and nearly straight on the ventral side. Length 30–40 μ , Breadth 10–18 μ .

Habitat : In pools above water-reservoir, Salt Range, Khewra Gorge.

October.

Plate IV, fig. 9.

Genus *Cymbella* Agardh, 1830.

Frustules asymmetrical, solitary or in colonies, free-floating or epiphytic, sessile or borne on stalks or enclosed in gelatinous tubes. Girdle straight or nearly sub-rectangular. Valve sublunate, attenuated from the middle towards the obtuse ends. Striæ punctate, radiate, delicate or coarse. Raphe arched, excentric with central and polar nodules. Axial area narrow or broad, slightly dilated in the middle, with one or more stigmas. Terminal fissures straight or curved towards the dorsal margin. Chromatophores one or more plate-like.

1. *Cymbella Ehrenbergii* Kütz. Pascher 1930, p. 356, fig. 656; Cleve 1894, p. 165; W. Smith 1853, p. 17, Pl. II, fig. 21.

Valve elliptic-lanceolate. Ends produced, obtuse. Striæ radiate, coarsely punctate. Raphe straight, slightly excentric. Axial area distinct, widened in the middle. Length 60–100 μ , Breadth 20–30 μ , Striæ 7–9 in 10 μ .

Habitat: In a small pool in the course of the stream where water-pipe crosses it, Salt Range, Khewra Gorge.

October.

Plate IV, fig. 1.

2. *Cymbella ventricosa* Kütz. Pascher 1930, p. 359, fig. 661; Boyer 1916, p. 62, Pl. 18, fig. 22.

Valve lunate, with dorsal side convex, and ventral straight or slightly gibbous in the middle. Ends produced, obtuse. Striæ punctate, radiate. Raphe straight. Axial area indistinct, narrow. Length 15–35 μ , Breadth 10–12 μ , Striæ 12–15 in 10 μ .

Habitat: In wooden troughs overgrown with *Cladophora* and *Vaucheria*, in Botanic Garden, Lahore. Water-reservoir near Engine House, Lahore. Rain-water pools and ponds all over the Province.

In pools, falls and rapids above reservoir, Salt Range, Khewra Gorge.

October–December.

Plate III, figs. 11, 12, 13.

Frustules of *C. ventricosa* are met with free-floating in large quantities, but in the salt water these occur mostly enclosed in gelatinous tubes. This species shows frequent variations as regards the outline of the valve. The ventral margin is sometimes straight or gibbous in the middle.

3. *Cymbella affinis* Kütz. Pascher 1930, p. 362, fig. 671a;
Cleve 1894, p. 171.

Valve broadly semi-elliptic, dorsal side strongly convex. Ends obtuse or subrostrate. Raphe slightly arcuate, excentric. Axial area narrow, with or without a punctum ventrally placed. Length 20–25 μ , Breadth 10–12 μ , Striæ 10–12 in 10 μ .

Habitat: In pools, rapids and falls above water reservoir, Salt Range, Khewra Gorge. Abundant.

October.

Plate IV, fig. 3.

4. *Cymbella excisa* (Kütz.) De Toni. Boyer 1916, p. 61,
Pl. 18, fig. 15.

Valve semi-elliptic, dorsal margin convex, ventral slightly convex, excised centrally. Raphe slightly arcuate. Axial area very narrow, sometimes indistinct, with a punctum ventrally placed. Striæ radiate, finely punctate. Length 25–30 μ , Breadth 12–15 μ , Striæ 15–20 in 10 μ .

Habitat: Among greenish filaments of *Spirogyra* Pond, Sangla. Rare.

December.

Plate IV, fig. 2.

5. *Cymbella cymbiformis* Kütz. Meister 1912, p. 182,
Pl. XXXI, fig. 4; Cleve 1894, p. 172.

Valve boat-shaped, with dorsal side convex, and ventral gibbous centrally. Ends obtuse. Raphe arcuate. Axial area

narrow, slightly dilated in the centre; isolated punctum indistinctly present (not shown in the figure). Striæ radiate, punctate or lineate. Length 63–75 μ , Breadth 10–15 μ , Striæ 8–9 in 10 μ .

Habitat: In pools, rapids and falls above water-reservoir, Salt Range, Khewra Gorge. Not common.

October.

Plate IV, fig. 4.

C. cymbiformis is encountered in association with *C. helvetica*.

6. *Cymbella* (?) *cistula* (Hempr.) Grun. Pascher 1930, p. 363, fig. 676a; Fritsch and Rich 1925, p. 110, fig. 7B; Cleve 1894, p. 173.

Valve boat-shaped, dorsal side convex, ventral side gibbous centrally. Ends broadly rounded rather truncate. Raphe arcuate. Axial area linear, squarish in the middle, with terminal fissure towards the dorsal side. Isolated puncta dim, present ventrally below the raphe. Striæ radiate, punctate or lineate. Length 90–110 μ , Breadth 25–30 μ , Striæ 6–8 in 10 μ .

Habitat: Among and epiphytic on brownish filaments in ponds, near Lahore.

October–January.

Plate IV, fig. 5.

All the forms met with here showed distinct median convexity of the ventral side which seems to be present along with the raphe. A dim puncta is also visible below the central nodule.

7. *Cymbella helvetica* var. *curta* Cl. Cleve 1894, p. 174; W. Smith 1853, p. 18, Pl. II, fig. 24.

Valve boat-shaped, dorsal side arcuate, ventral side gently swollen at the centre. Raphe almost straight. Axial area very narrow, with straight terminal fissure. Isolated puncta, below the central nodule. Striæ radiate, fine. Length 40–45 μ , Breadth 10–12 μ , Striæ 11–12 in 10 μ .

Habitat: In pools, ponds and rapids, Salt Range, Khewra Gorge. Very common.

October.

Plate IV, fig. 6.

Genus *Gomphonema* Agardh, 1824.

Frustules solitary or in groups, sessile or borne on gelatinous stalks. Girdle cuneate. Valve lanceolate or clavate, sinuate towards the margin. Ends obtuse or capitate. Striæ lineate or punctate; punctæ delicate or bead-like. Raphe straight with polar and central nodules. Axial area narrow, inflexed in the middle, containing an isolated, unilateral puncta (or stigma). Chromatophores one or more, broadly lobed, extending over the entire valve-face.

1. *Gomphonema Ghosea* * n.sp.

Frustules epiphytic. Girdle straight, cuneate. Valve clavate, attenuated towards base and gibbous towards the upper part with pin-head like apex. Striæ lineate or closely punctate. Axial area narrow, linear with an isolated punctum on one side of the central nodule. Chromatophores two, elongated with irregular lobes. Length 30–40 μ , Breadth 10–12 μ , Striæ 10–12 in 10 μ .

Habitat: Epiphytic on fallen twigs forming brownish film, Shahlamar Garden Tanks, Lahore. Among and epiphytic on green algal filaments, attached to reeds, in pond near Lahore.

November–December.

Plate III, figs. 1, 2, 3.

G. Ghosea appears to be an altogether distinct species comparable to *G. sphaerophorum* Ehr. and *G. constrictum* Ehr. The noteworthy characteristics are:—Valve with gibbous middle region and narrow base; Pin-head like apex; Striæ lineate, slightly converging in the middle; An isolated punctum (or stigma). Individuals occur epiphytically in twos or in

* This species is named after my esteemed teacher Dr. S. L. Ghose, F.L.S., Professor of Botany, Government College, Lahore.

threes, on dichotomously branched, mucilaginous, hyaline stalks.

2. **Gomphonema olivaceum** var. **calcareum** Cl. Pascher 1930, p. 379, fig. 721; Cleve 1894, p. 188.

Valve clavate, broad obtuse apex and drawn out base. Axial area narrow with rectangular central area. Striæ lineate, parallel, radiating in middle. Raphe straight. Length 40-45 μ , Breadth 8-10 μ , Striæ 12-13 in 10 μ .

Habitat: Among and epiphytic on brownish filaments in a pond near Lahore. A pond near Railway Station, Gujranwala. December-January.

Plate II, fig. 21.

In the material brought from Gujranwala some forms did not show the thinned portion of the apex.

Sessile frustules are often encountered in the collection; they have broken away from the stalks, to which they were epiphytically attached.

3. **Gomphonema abbreviatum** (Ag. ?) Kütz. Pascher 1930, p. 379, fig. 722; Meister 1912, p. 174, Pl. XXIX, fig. 17.

Frustules in groups of 2 or 3 or more, epiphytic on *Cladophora*. Girdle wedge-shaped. Valve clavate, broad and rounded at the apex narrowing towards the base. Axial area narrow. Length 15-30 μ , Breadth 4-5 μ .

Habitat: Epiphytically attached to *Cladophora* growing on the sides of boats, in running water, the river Sutlej, at Rupar.

November-December.

Plate IV, figs. 10, 11, 12.

4. **Gomphonema subapicatum** Fritsch and Rich. Fritsch and Rich 1929, p. 109, figs. 6A-B.

Valve clavate, broadened a little above the middle, gradually tapering towards the apex and base, the latter

rounded. Raphe straight. Striæ punctate, farther apart in the middle. Axial area narrow. Stigma present. Length 60–70 μ , Breadth 12–14 μ , Striæ 12 in 10 μ .

Habitat: In greyish fascicles attached to the blades of the *Typha* plant, in a pond near Lahore.

December–January.

Plate III, fig. 4.

***Gomphonema subapicatum* f. *curta* Fritsch and Rich.**

Fritsch and Rich 1929, p. 109, figs. 6 C–D.

Valve broader in the middle than the type. Length 30–40 μ , Breadth 10–11 μ , Striæ 12 in 10 μ .

Habitat: Brownish filmy layer on water plants, Shahlamar Garden Tanks, Lahore. Rare.

November.

Plate III, fig. 5.

13. Family Epithemiaceæ.

(a) Sub-family Epithemioideæ.

Genus *Denticula* Kützing, 1844.

Frustules solitary, mostly united to form short band-like filaments. Girdle sub-rectangular, sides slightly convex and ends truncate; transverse septa parallel with capitate ends at the juncture of the valve and girdle, between them are rows of fine punctae. Valve lanceolate with transverse ribs extending across its face. Pseudoraphe absent.

(The genus has a very much disputed position in the classification. "The assumed lack of a raphe has led most investigators to place the genus in the Fragilariaceæ and to consider it closely related to *Tetracyclus* and *Diatomella*. The marginal raphe shows that it is closely related to *Nitzschia* and *Hantzschia*." Gilbert M. Smith 1933, p. 267.)

1. **Denticula crassula** Naeg. Schönfeldt 1907, p. 93,
Pl. 5, figs. 21, 21a.

Frustules forming short band of filaments united together along their edges. Girdle sub-rectangular. Ends truncate. Valve elliptical. Length 20–26 μ , Breadth 8–10 μ .

Habitat: In pools, rapids and falls above water-reservoir, Salt Range, Khewra Gorge.

October.

Plate I, fig. 12.

The frustules of *D. crassula* are always in groups of three or four united along their edges and the girdle is often visible under the microscope.

Genus **Epithemia** Brébisson, 1838.

Frustules solitary, free-floating or epiphytic. Girdle rectangular or broadly elliptical with truncate ends. Valve arcuate slightly tumid in middle. Dorsal side convex and ventral concave. Ends broadly rounded or sub-capitate. Costæ transverse, across the face between which two or more rows of punctæ. Raphe V-shaped in the middle, running along the ventral valve-face. Chromatophores one or two plate-like. Auxospores formed in pairs.

1. **Epithemia argus** Kütz. Pascher 1930, p. 383, fig. 727a;
Meister 1912, p. 198, Pl. XXXIV, fig. 6.

Frustules solitary or in groups, attached to some submerged aquatics. Valve arcuate, dorsal side convex, and ventral plano-concave. Ends rounded. Raphe curved, V-shaped on the ventral side. Length 45–60 μ , Breadth 12–15 μ , Costæ 4 in 10 μ .

Habitat: Attached to and covering brownish thread-like filaments in a pond near Lahore. Very common.

December–January.

Plate V, figs. 11, 12.

The ventral side of the valve appears straight in many forms and the raphe also shows a slightly lesser angle.

E. argus and *E. turgida* are encountered together and found abundantly.

2. ***Epithemia turgida*** (Ehr.) Kütz. Pascher 1930, p. 387, fig. 733; Boyer 1916, p. 111, Pl. 31, fig. 14.

Valve slightly arcuate, ventral side slightly concave, and dorsal convex. Ends attenuated, subcapitate. Costæ transverse, between them 2 rows of dim punctæ. Raphe arched in the middle and later on run along the ventral margin. Length 120–150 μ , Breadth 15–18 μ , Costæ 3–5 in 10 μ .

Habitat: Attached to and covering brownish thread-like filaments in a pond near Lahore. Abundant.

December–January.

Plate V, fig. 13.

3. ***Epithemia Hyndmanni*** W. Smith. Pascher 1930, p. 387, fig. 735; W. Smith 1853, p. 12, Pl. I, fig. 1.

Valve greatly arched, dorsal and ventral sides strongly curved. Ends narrow, obtuse. Costæ transverse, punctæ indistinct. Length 180–200 μ , Breadth 14–20 μ , Costæ 4–5 in 10 μ .

Habitat: Amongst greyish fascicles attached to the blades of *Typha* plant in a pond, near Lahore. Rather rare.

January.

Plate V, fig. 14.

In some specimens the raphe has its angle very much stretched in the middle, so much so that its sides seem to run near the dorsal margin of the valve.

(b) Sub-family Rhopalodioideæ.

Genus ***Rhopalodia*** O. Müller, 1895.

Frustules solitary or in groups, free-floating. Girdle linear or elliptical, broad in middle with rounded poles. Valve elongate or lunate, dorsal side convex, inflated in the middle.

Ends acute or incurved. Costæ transverse and well-marked, intervening one or two rows of delicate striæ. Raphe along the convex edge, situated in keel-like portion, with indistinct central and polar nodules. Chromatophore one, elongate, irregularly lobed.

1. **Rhopalodia gibba** (Ehr.) O. Müll. G. M. Smith 1933, p. 263, fig. 186; West and Fritsch 1927, p. 381, fig. 163A; Boyer 1916, p. 112, Pl. 31, fig. 23.

Frustules solitary or in groups, linear with medianly inflated sides narrowing towards the broadly rounded ends. Valve linear, dorsal side arcuate and ventral straight, but bent (or reflexed) at the ends. Ends acute. Costæ transverse. Length 80–100 μ , Breadth 15–20 μ , Costæ 6–8 in 10 μ .

Habitat: Among and epiphytic on the brownish filaments in ponds near Lahore. Pools formed by the overflow of water of the river Ravi. Very commonly met with in the Central Panjab.

November–April.

Plate IV, figs. 13, 14, 15.

It is often the girdle view that is viewed under the microscope.

Species of *Rhopalodia* and *Epithemia* are always found in close association.

2. **Rhopalodia ventricosa** (Kütz.) O. Müll. Boyer 1916, p. 112, Pl. 31, fig. 24; Pascher 1913, p. 147, fig. 325.

Valve linear, gibbous in the middle with sub-parallel sides. Ends a little reflexed. Costæ parallel. Length 50–65 μ , Breadth 10–12 μ , Costæ 5–8 in 10 μ .

Habitat: In the brownish epiphytic mass on the algal and other water-plants, Shahlamar Garden Tanks, Lahore. Ponds and pools near the Canal, Amritsar.

December–January.

Plate V, fig. 16.

3. *Rhopalodia gibberula* (Ehr.) O. Müll. Pascher 1913,
p. 148, fig. 326.

Valve gibbous on the dorsal side, ventral side straight. Girdle rhombic-elliptical. Costæ transverse, radiate. Length 30-40 μ , Breadth 12 μ , Costæ 5-8 in 10 μ .

Habitat: Among brownish filaments in ponds near Lahore. In pools formed by the water of the river Ravi.

December-January.

Plate V, fig. 15.

14. Family Nitzschiaceæ.

(a) Sub-family Nitzschioidæ.

Genus *Nitzschia* Hassall, 1845.

Frustules solitary and free-floating or in groups. Girdle straight, elongate or sigmoid with truncate ends. Valve straight, linear or elliptical, attenuated to acute, or subrostrate ends. Keels (with raphe) of the two valves diagonally opposite. Carinal dots conspicuously present. Striæ transverse, punctæ coarse or fine. Chromatophores one or two elongate, with irregular margins.

Section *Tryblionellæ* (W. Smith, Grun.) Hust.

Frustules mostly elliptic-lanceolate. Keel excentric. Valve folded. Keel-punctæ indistinct.

1. *Nitzschia punctata* var. *obtusa* nov. var.

Valve linear-elliptical, rounded at the ends. Striæ transverse, parallel, punctate; punctæ coarse. Longitudinal fold prominent. Length 45-50 μ , Breadth 10-12 μ , Striæ 7-8 μ .

Habitat: In pools above water-reservoir, Salt Range, Khewra Gorge.

Plate V, fig. 1.

The variety has distinct characteristic obtuse ends and the valve is slightly broad in the middle.

2. *Nitzschia angustata* var. *genuina* Meister. Meister 1912, p. 205, Pl. XXXVI, fig. 7.

Valve linear-lanceolate, swollen centrally towards the keel side. Ends blunt. Keel marginal. Carinal dots continued into striæ. Striæ lineate, parallel. Length 65–70 μ , Breadth 10–15 μ , Striæ 11–15 in 10 μ .

Habitat: In a pool above water-reservoir, Salt Range, Khewra Gorge.

October.

Plate V, fig. 2.

Section *Lineares* (Grun.) Hust.

Frustules straight. Keel excentric with angular punctæ. Longitudinal fold absent.

1. *Nitzschia linearis* W. Smith. Pascher 1930, p. 409, fig. 784; Meister 1912, p. 211, Pl. XXXVIII, fig. 4; W. Smith 1853, p. 39, Pl. XXXI, fig. 110.

Valve straight, linear. Ends slightly acuminate, striæ obscure. Punctæ in a single row. Length 70–80 μ , Breadth 6 μ .

Habitat: On moist wet ground, outside Panjab University Botanical Laboratory, Lahore.

November.

Plate V, fig. 3.

Section *Lanceolatae* Grun.

Valve linear-lanceolate. Keel excentric with punctæ not extended.

1. *Nitzschia Heufleriana* Grun. Pascher 1930, p. 414, fig. 805; Meister 1912, p. 212, Pl. XXXVIII, fig. 8.

Valve linear, narrow with sides parallel centrally and thinned at the ends. Keel marginal placed towards the concave side. Carinal dots present. Ends rather drawn out

and pointed. Length 60–70 μ , Breadth 5–6 μ , Carinal dots 10 in 10 μ .

Habitat: Among green algal scum on earthen pots placed in the Green House, outside Panjab University Botanical Laboratory, Lahore. Rare.

December.

Plate V, fig. 4.

The specimen figured here has its valve centrally curved.

2. *Nitzschia subtilis* Kütz. Van Heurck 1899, p. 401, Pl. 17, fig. 553.

Valve minute, linear-lanceolate. Keel present. Striæ obscure or absent. Length 10–30 μ , Breadth 3–5 μ .

Habitat: On moist wet ground, Nasir Mound and Shahlamar Garden in Lahore. Drying edges of pools in Gujranwala and Amritsar. Commonly found in the Panjab.

Throughout the year.

October–January (mostly).

Plate V, figs. 5, 6, 7.

N. subtilis is found in association with many other common species of *Nitzschia*.

3. *Nitzschia palea* (Kütz.) W. Smith. Boyer 1916, p. 122, Pl. 32, fig. 15; Pascher 1913, p. 159, fig. 352.

Frustules solitary. Girdle linear with truncate ends. Valve linear-lanceolate. Striæ obscure, but carinal dots in the keel quite conspicuous. Length 30–50 μ , Breadth 4–6 μ .

Habitat: On moist soil, in ponds, tanks in Lahore, Jullundur, Sialkote and Gujranwala. Profusely abundant in the Panjab.

This species is also very commonly met with in the Salt Range, Khewra Gorge.

At all times in the Panjab.

October (in salt water).

Plate VI, figs. 2, 3.

N. palea has a considerable range as regards its length and therefore some of the specimens may be mistaken for

N. linearis, but it differs from the former in the gradual attenuation of the valves from the middle towards the acute ends.

Section **Sigmoideæ** (Grun.) Hust.

Frustules sigmoid. Keel nearly central. Keel-punctæ in a double row.

1. **Nitzschia vermicularis** (Kütz.) Grun. Pascher 1930, p. 419, fig. 811; Boyer 1916, p. 120, Pl. 33, fig. 9.

Frustules solitary. Girdle sigmoid with truncate ends. Valve sigmoid, linear, slightly attenuated towards the end. Keel punctate. Length 90–180 μ , Breadth 6–12 μ .

Habitat: In the greenish mass covering some gastropod-shells, the Small Ravi, Lahore. Among greenish filaments at the bottom of garden streamlets, Ambala, Gujranwala and Sangla.

In a pool, Salt Range, Khewra Gorge.

October–December.

Plate V, figs. 8, 9, 10.

15. Family **Surirellaceæ**.

(a) Sub-family **Surirelloideæ**.

Genus **Cymatopleura** W. Smith, 1851.

Frustules solitary or free-floating. Girdle linear with margin markedly undulate. Valve oblong or linear or fiddle-shaped, transversely undulate. Keel marginal containing raphe and short costæ along both sides. Striæ fine interrupted by an inconspicuous pseudoraphe. Chromatophores one or two along the valve.

1. **Cymatopleura solea** (Bréb.) W. Smith. Pascher 1930, p. 425, fig. 823a; W. Smith 1853, p. 36, Pl. X, fig. 78.

Girdle linear, sides markedly undulate, six undulations in some. Valve fiddle-shaped. Ends acute. Pseudoraphe scarcely visible. Length 100–120 μ , Breadth 25–35 μ , Costæ 6–8 in 10 μ .

Habitat: Among brownish filaments of some algæ, in a pond near Lahore. Rather rare.

December.

Plate VI, fig. 4.

Genus **Surirella** Turpin, 1828.

Frustules solitary or free-floating. Girdle sub-rectangular or cuneate. Valve linear, elliptical or ovate. Ends rounded or sub-acute. Keel marginal containing a raphe. Costæ short, transverse, parallel reaching the pseudoraphe; intercostal striæ fine and delicate. Pseudoraphe centrally placed, linear or lanceolate. Chromatophores two, lying along the girdle, and joined by a bridge-like connection in the middle or split up into numerous irregularly rounded granules.

1. **Surirella ovalis** Bréb. Pascher 1930, p. 441, fig. 860;
Boyer 1916, p. 126, Pl. 35, fig. 5.

Valve ovate. Costæ short, marginal, radiate. Intercostal striæ and pseudoraphe scarcely visible. Length 50–60 μ , Breadth 30–35 μ , Costæ 4–5 in 10 μ .

Habitat: Amongst brownish scum on the sides and greenish filaments in drying ponds, Gujranwala and Hafizabad. In abundance.

December.

Plate VI, fig. 5.

2. **Surirella tenera** Greg. Pascher 1930, p. 438, fig. 853;
Boyer 1916, p. 125, Pl. 35, fig. 6.

Valve ovate, upper end broad and lower tapering. Pseudoraphe narrow, streak-like. Costæ parallel in middle, convergent at ends. Keel marginal, forming wing. Length 60–70 μ , Breadth 24–30 μ , Costæ 3 in 10 μ .

Habitat: In greenish scum in a drain, Railway Station, Gujranwala. On the edges of a drying pond, near Old Church, Hafizabad.

December.

Plate VI, fig. 7.

3. **Surirella splendida** var. **minor** Meister. Meister 1912,
p. 227, Pl. XLIV, fig. 3.

Valve ovate, elongated. Pseudoraphe linear or lanceolate.
Costæ radiate, short, marginal, reaching the middle of the valve.
Length 100–110 μ , Breadth 40–50 μ , Costæ 3–4 in 10 μ .

Habitat: On the edges of a drying pond near Green
House, Botanic Garden, Lahore. Rare.

December.

Plate VI, fig. 6.

CONCLUSION.

The study of Diatoms especially from a systematic point of view is beset with difficulties. The fact that the literature required is scattered in many foreign languages, and the existence of occasional contradictory views of authorities about the systematic groups have made it an extremely trying piece of work.

This short treatise, in fact, forms a basis on which advanced work may be built. I have not attempted to investigate the cytology or reproduction, because I feel that after more careful and judicious research has been carried on and better knowledge of the group thus obtained, these points can be dealt with satisfactorily. Our knowledge of the Panjab Diatoms is yet rather meagre.

I am highly indebted to Dr. S. L. Ghose, F.L.S., for his valuable suggestions, criticism and guidance during the course of my research ; and it is only through his encouragement that I have been able to finish this piece of work. Thanks are also due to Drs. S. L. Hora and H. S. Pruthi for their having sent the collection from the Khewra Gorge.

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PLATES.

PLATE I.

- 1, 2, 3. *Melosira varians* Ag.
- 4, 5. *M. italica* (Kütz.) W. Smith.
6. *M. crenulata* (Ehr.) Kütz.
- 7, 8, 9. *Cyclotella operculata* Kütz.
- 10, 11. *C. Kützingiana* Thw.
12. *Denticula crassula* Naeg.
- 13, 14. *Diatoma vulgare* Bory.
15. *Synedra affinis* Kütz.
16. *S. rumpens* Kütz.
- 17, 18. *Cocconeis placentula* var. *lineata* V.H.
19. *Diploneis puella* (Schu.) Cl.
20. *D. elliptica* Kütz.

Plate I.

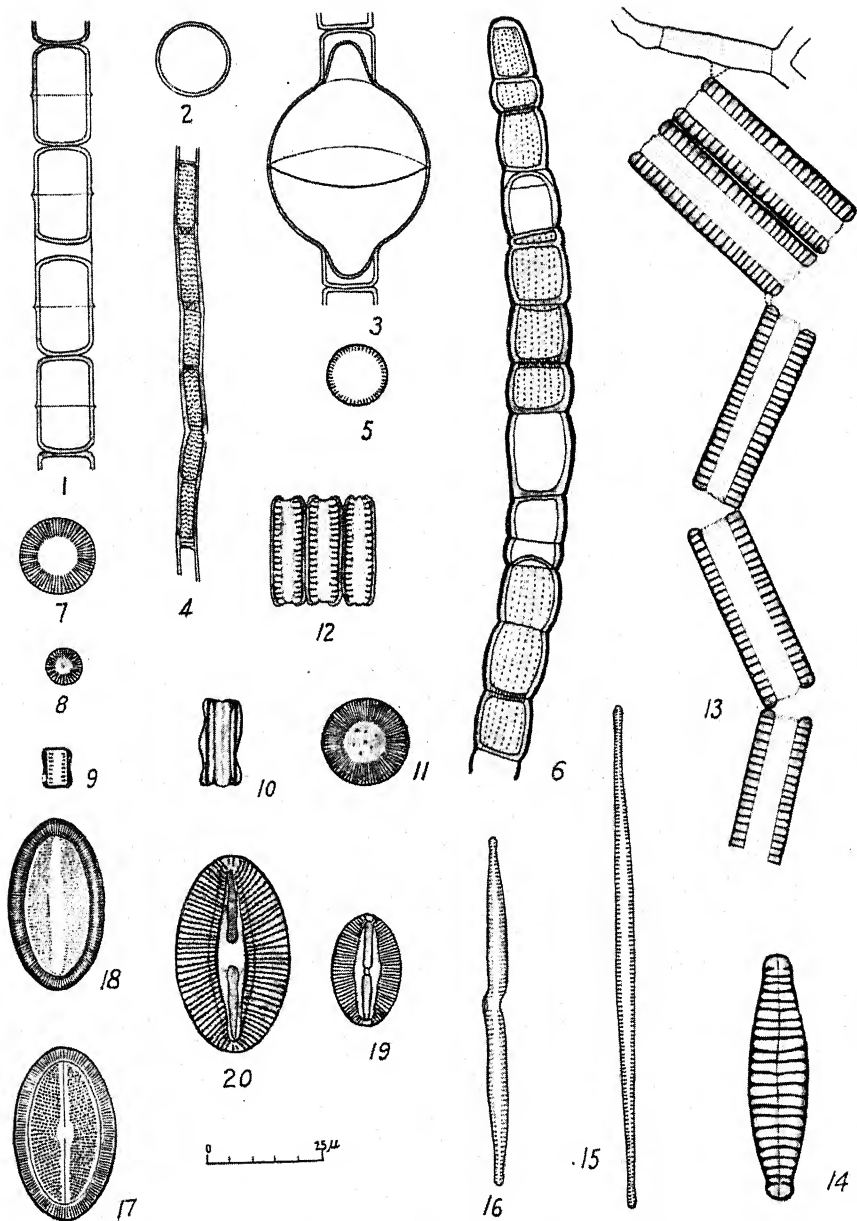


PLATE II.

- 1, 2. *Synedra ulna* var. *amphirhynchus* (Ehr.) Grun.
3. *S. capitata* Ehr.
4. *Eunotia arcus* Ehr.
- 5, 6. *E. minuta* n.sp.
- 7, 8. *Achnanthes hungarica* Grun.
- 9, 10, 11. *A. hungarica* var. *linearis* nov. var.
- 12, 13. *Cocconeis pediculus* Ehr.
- 14, 15. *C. placentula* Ehr.
- 16, 17. *Diatoma elongatum* Ag.
18. *Navicula viridula* var. *rostellata* Cl.
19. *N. radiosa* var. *acuta* Grun.
20. *Pinnularia interrupta* W. Smith.
21. *Gomphonema olivaceum* var. *calcareum* Cl.
- 22, 23, 24. *Navicula* (?) sp.

Plate II.

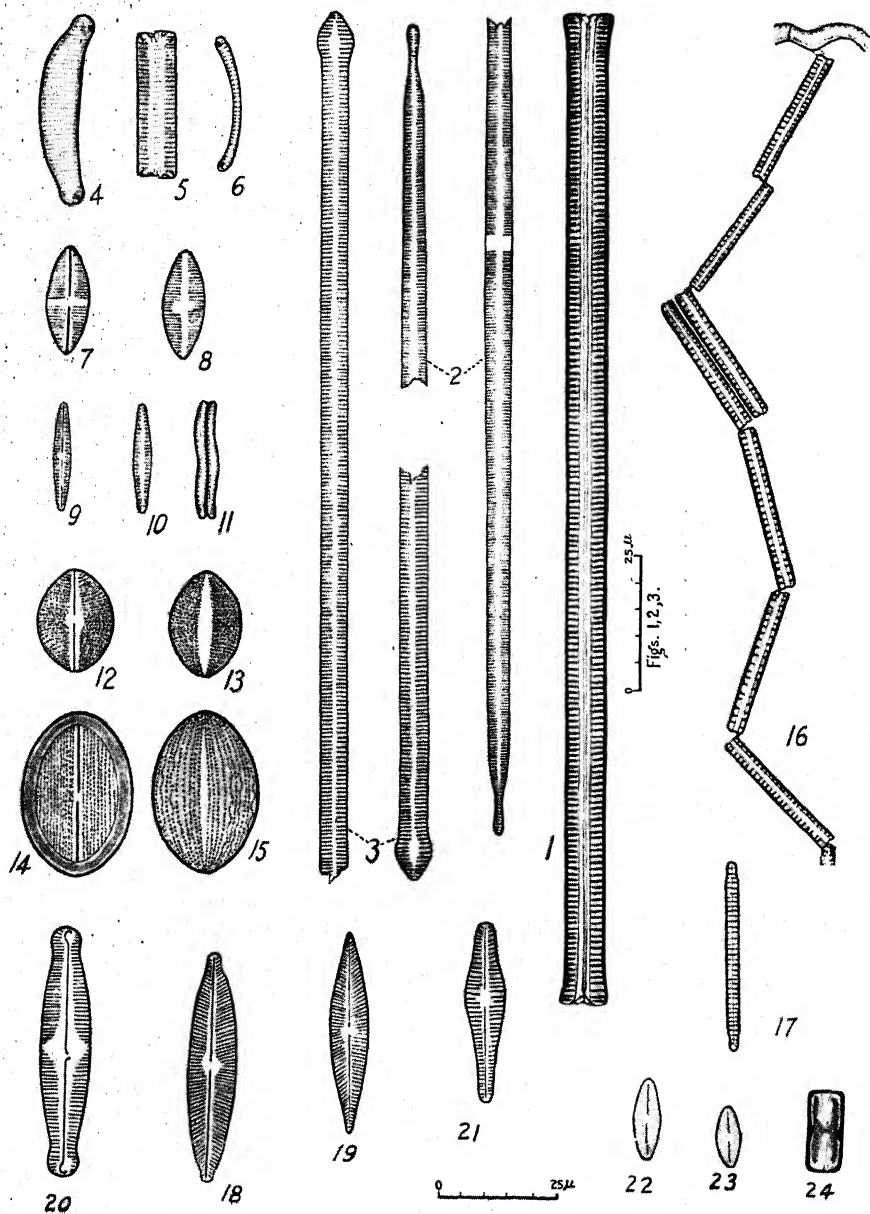


PLATE III.

- 1, 2, 3. *Gomphonema Ghosea* n.sp.
4. *G. subapicatum* Fritsch and Rich.
5. *G. subapicatum* f. *curta* Fritsch and Rich.
6. *Gyrosigma acuminatum* (Kütz.) Rabh.
7. *G. scalproides* (Rabh.) Cl.
8. *G. tenuissimum* W. Smith.
9. *Anomoeoneis sphaerophora* (Kütz.) Pfitz.
10. *Pinnularia gibba* Ehr.
- 11, 12, 13. *Cymbella ventricosa* Kütz.

Plate III.

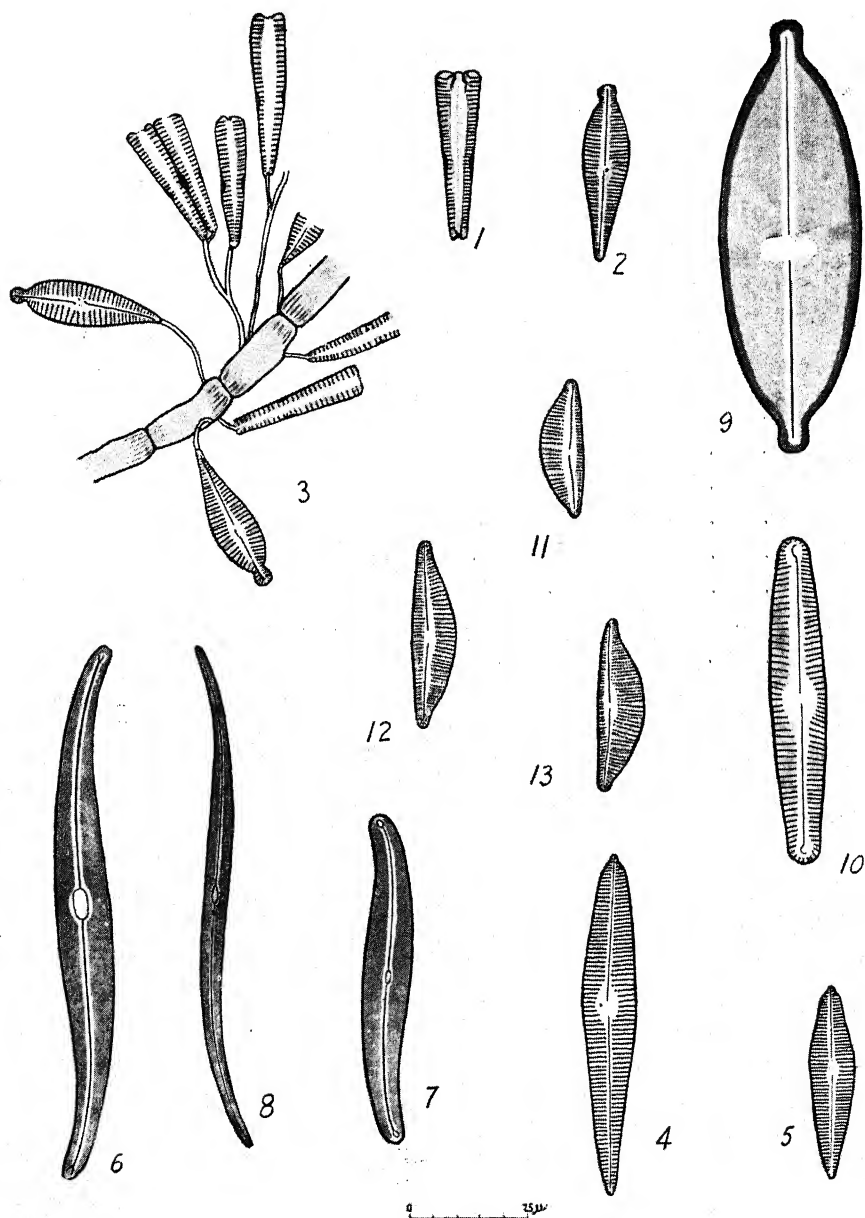


PLATE IV.

1. *Cymbella Ehrenbergii* Kütz.
2. *C. excisa* (Kütz.) De Toni.
3. *C. affinis* Kütz.
4. *C. cymbiformis* Kütz.
5. *C. (?) cistula* (Hempr.) Grun.
6. *C. helvetica* var. *curta* Cl.
- 7, 8. *Amphora ovalis* var. *gracilis* V.H.
9. *A. coffeaeformis* Ag.
- 10, 11, 12. *Gomphonema abbreviatum* (Ag. ?) Kütz.
- 13, 14, 15. *Rhopalodia gibba* (Ehr.) O. Müll.

Plate IV.

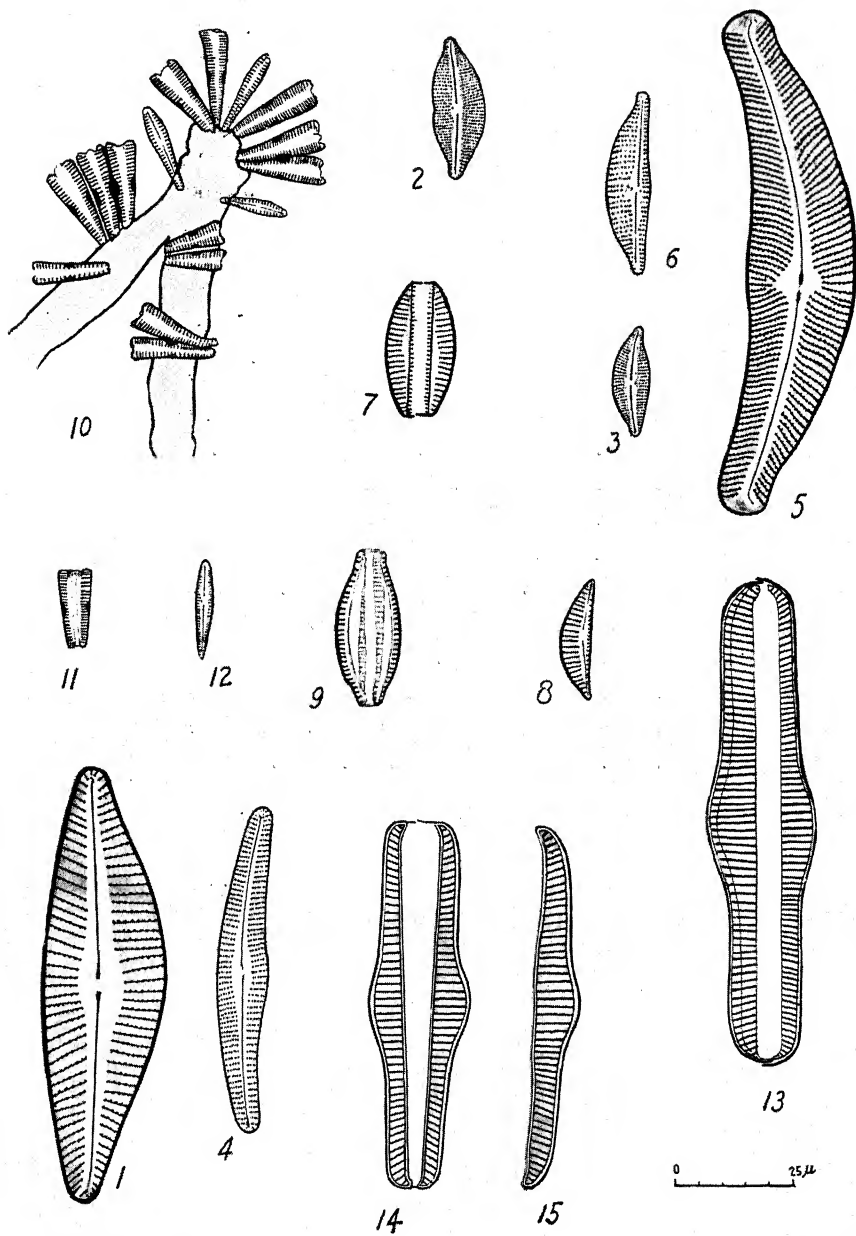


PLATE V.

1. *Nitzschia punctata* var. *obtusa* nov. var.
2. *N. angustata* var. *genuina* Meister.
3. *N. linearis* W. Smith.
4. *N. Heufleriana* Grun.
- 5, 6, 7. *N. subtilis* Kütz.
- 8, 9, 10. *N. vermicularis* (Kütz.) Grun.
- 11, 12. *Epithemia argus* Kütz.
13. *E. turgida* (Ehr.) Kütz.
14. *E. Hyndmanni* W. Smith.
15. *Rhopalodia gibberula* (Ehr.) O. Müll.
16. *R. ventricosa* (Kütz.) O. Müll.

Plate V.

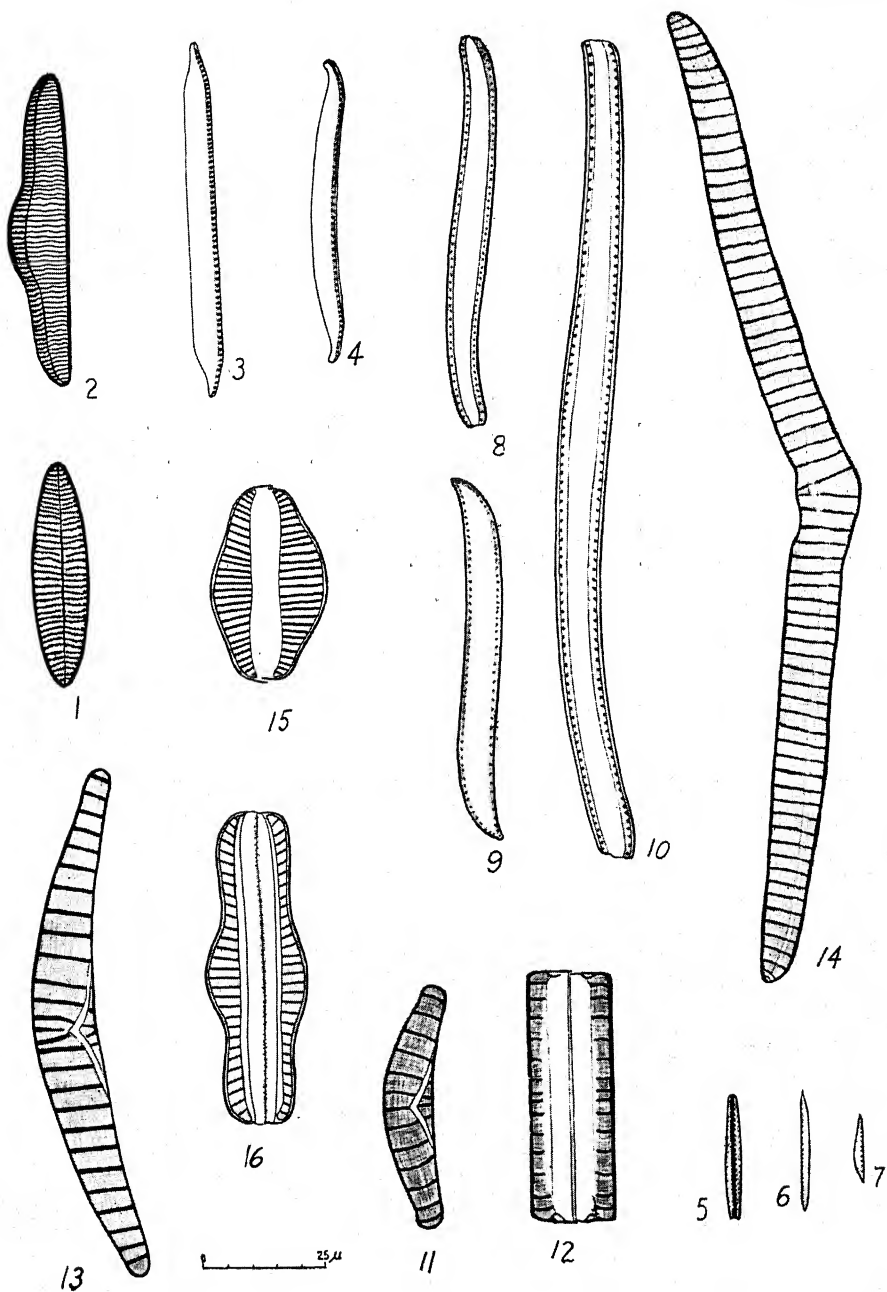


PLATE VI.

1. *Navicula cuspidata* var. *major* Meister.
- 2, 3. *Nitzschia palea* (Kütz.) W. Smith.
4. *Cymatopleura solea* (Bréb.) W. Smith.
5. *Surirella ovalis* Bréb.
6. *S. splendida* var. *minor* Meister.
7. *S. tenera* Greg.

Plate VI.

